6.5.4 Uncertainty and the Role of Conservatism in the Compliance Demonstration

As defined in 40 CFR § 191.12, ~~performance assessments~~***PAs*** must "estimate the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant events and processes."

Site characterization, repository design, and waste characterization activities, as described in Chapters 2.0, 3.0, and 4.0, respectively, have removed much uncertainty from the analysis. Uncertainties remain, however, about how best to characterize some aspects of the disposal system and how best to model the complex interactions between the waste and its surrounding environment. These remaining uncertainties have been incorporated in the performance assessment to the extent practicable through the use of reasonable and realistic assumptions about models and parameter values.

In general, the DOE has not attempted to bias the ~~performance assessment~~***PA*** toward a conservative outcome, and the mean CCDF represents a reasonable estimate of the expected and, in the case of future human activities including intrusion, prescribed, performance of the disposal system. However, where realistic approaches to incorporating uncertainty are unavailable or impractical and where the impact of the uncertainty on performance is small, the DOE has chosen to simplify the analysis by implementing reasonable and conservative assumptions. These conservative assumptions are reviewed here, not because they bias the location of the mean CCDF, but rather because an understanding of their effects contributes qualitatively to the "reasonable expectation, on the basis of the record before the implementing agency, that compliance with [§] 191.13(a) will be achieved," as required by ~~40 CFR §~~***Section*** 191.13(b).

As noted in Section 6.2 and Appendix ***PA, Attachment*** SCR, in some cases processes have been omitted from the modeling system for simplicity because the only possible effects of including them would be beneficial to system performance. Examples include the decision to model radionuclide dissolution as an equilibrium process (assuming instantaneous leaching and dissolution), and the decision not to model sorption of radionuclides in the Salado or in the seal system.

In other cases, the DOE has made conservative decisions during the design of the conceptual and computational models, as listed in Table ***6-32*** ~~6-30~~. Some conservative assumptions listed in this table are mentioned below. For example, within the repository portion of the BRAGFLO model, fluid flow in a single panel is treated as if all rooms were a single void (that is, pillars are omitted). This treatment allows brine flow to and from an intrusion borehole to contact more waste than it would if it followed a more realistic flow path between rooms. The effect is conservative with respect to brine flow up a plugged and abandoned borehole. Similarly, the DOE has chosen to model fluid flow through plugged and abandoned boreholes as if all intrusions occurred into a down-dip (that is, southern) panel. As modeled, downdip panels tend to have more brine in them than up-dip panels ***(see Appendix PA, Section PA-8.0)*** and this assumption therefore may result in overestimating the amount of brine present in intruded panels.

Radionuclide dissolution to solubility limits is modeled as instantaneous. ~~The DRZ around the panel closures is assumed not to heal and panel closures are assumed to be no more effective than the surrounding DRZ, tending to overestimate the amound of fluid flow between panels.~~

For E1E2 scenarios, complete mixing is assumed within the intruded panel, and all brine that flows out of the panel and up the borehole is assumed to have been in contact with waste.

Within the shaft seal system, concrete components are modeled as if they degrade ~~400 years~~ after emplacement, underestimating their potential to limit fluid flow over the long-term. For direct releases and E1E2 releases to the Culebra, processes of actinide transport and retardation are not modeled within the intrusion borehole and all actinides that enter the borehole are assumed to be transported to the surface or into an overlying transmissive unit. Within the Culebra (which modeling indicates will be the only transmissive unit that will receive long-term flow from the borehole), hydraulically significant fractures are assumed for modeling simplicity to be present everywhere, even though test data indicate that the portions of the Culebra above the waste disposal region behave as an unfractured, single porosity matrix.

These conservative assumptions have not significantly affected the location of the mean CCDF, which, as shown in Section 6.5.3, is dominated by cuttings and cavings releases that are, with one exception, independent of the conservative simplifications described here. As discussed in Appendix ~~SA~~***PA*** ~~(Section SA.1)~~, the parameter making the largest contribution to uncertainty in the location of the mean CCDF is the effective shear resistance of the waste, which affects the quantity of waste eroded from the borehole wall and transported to the surface as cavings. In the absence of data describing the reasonable and realistic future properties of degraded waste and ~~backfill~~ ***MgO***, effective shear resistance of the waste is a parameter for which the DOE has selected a conservative distribution (see Appendix PAR, Parameter 33).

6.5.5 Summary of the Demonstration of Compliance with the Containment Requirements

The WIPP ~~is~~***continues to comply*** ~~in compliance~~ with the containment requirements of 40 CFR § 191.13(a), as shown by Figures ~~6-35~~***6-34*** through ~~6-39~~***6-38***. Figures ~~6-38~~***6-37*** and ~~6-39~~***6-38*** demonstrate that the sample size of 100 chosen for this analysis is sufficient to provide the level of statistical confidence specified in 40 CFR § 194.34.

Additional confidence in the compliance determination comes from examination of Figure ~~6-41~~***6-39***, which shows that the location of the mean CCDF depends almost entirely on the relatively simple processes that contribute to cuttings and cavings releases resulting from inadvertent human intrusion by drilling. Uncertainties related to the characterization of the natural system and the interaction of waste with the disposal system environment have little effect on long-term performance. The natural and engineered barrier systems, as described in Chapters 2.0 and 3.0, ***will*** provide robust and effective containment of TRU waste even if the repository is penetrated by multiple borehole intrusions.

Table *6-32*~~6-30~~. Conservative Model and Parameter Assumptions Used in ~~Performance Assessment~~*PA* (from Appendix *PA, Attachment* MASS, Table MASS-1)

Conservative Assumption	Code	Cross-Reference
Long-term flow up plugged and abandoned boreholes is modeled as if all intrusions occur into a down-dip (southern) panel.	BRAGFLO	Section 6.4.3
Pillars, individual drifts ~~in~~ ***and*** rooms~~, and panel closures in the nine lumped panels,~~ are not modeled for long-term performance, and containers provide no barrier to fluid flow.	BRAGFLO	Section 6.4.3, Appendix ***PA, Attachment*** MASS, Section ~~MASS.~~5.***0***
~~Panel closures are modeled with the same permeability as the surrounding DRZ.~~	~~BRAGFLO~~	~~Sections 6.4.3.2 and 6.4.5.3~~ ~~MASS Attachment 7-1~~
Brine in the repository will contain a uniform mixture of dissolved and solid-state species. ***All actinides have instant access to all repository brine.*** ~~No microenvironments that influence the overall chemical conditions will persist.~~	NUTS PANEL	Section 6.4.3.4 Appendix ***PA, Attachment*** SOTERM, Section ~~SOTERM.~~2.2
Radionuclide dissolution to solubility limits is instantaneous.	NUTS PANEL	Sections 6.4.3.5 and 6.4.3.4 (Appendix ***PA, Attachment*** SOTERM, Section ~~SOTERM.~~3.3, ~~SCR.2.5.3.1~~)
Radionuclides are not retarded by shaft seals.	NUTS	Section 6.4.4 ~~Section SCR.2.5.4.2~~
Shaft concrete components ***of the lower shaft*** are modeled as if they degrade ~~400 years~~ after emplacement.	BRAGFLO	Section 6.4.4 Appendix ***PA, Attachment*** PAR~~, Table PAR-19~~
The permeability of the DRZ is ~~constant and higher than intact Salado.~~ ***sampled with the low value similar to intact halite and the higher value representing a fractured material.***	BRAGFLO	Section 6.4.5.3 Appendix ***PA, Attachment*** MASS, Section ~~MASS.~~13.4
The ~~unnamed lower member,~~ ***Los Medaños member of the Rustler,*** Tamarisk, and Forty-niner are assumed to be impermeable.	BRAGFLO SECOFL2D	Sections 6.4.6.1, 6.4.6.3, and 6.4.6.5 Appendix ***PA, Attachment*** MASS, Section ~~MASS.~~14.***0***
Sorption of actinides in the borehole is not modeled.	***NUTS***	***Section 6.4.5.4*** ***Appendix PA, Attachment MASS, Section 13.5***
Sorption occurs on dolomite in the matrix. Sorption on clays present in the Culebra is not modeled.	~~SECOFL2D~~***SECOTP2D***	Section 6.4.6.2.1 Appendix ***PA, Attachment*** MASS, Section ~~MASS.~~15.2
Particle waste shear ***is*** based on properties of marine clays, considered a worst case.	CUTTINGS_S	Section 6.4.7.1 Appendix ***PA, Attachment*** PAR~~, Parameter 33~~
The concentration of actinides in liquid moving up the borehole in the E1E2 scenario assumes homogeneous mixing within the panel.	CCDFGF PANEL	Section 6.4.13.5

Table *6-32* ~~6-30~~. Conservative Model and Parameter Assumptions Used in ~~Performance Assessment~~*PA* (from Appendix *PA, Attachment* MASS, Table MASS-1) — Continued

Conservative Assumption	Code	Cross-Reference
For all direct releases to the surface and the E1E2 source term to the Culebra, any actinides that enter the borehole are assumed to reach the surface or Culebra***, respectively***.	CUTTINGS_S ***DRSPALL*** BRAGFLO~~_DBR~~ PANEL CCDFGF	Section 6.4.7.1 Section 6.4.13.5
A hemispherical geometry with one-dimensional spherical symmetry defines the flow field and cavity in the waste	***DRSPALL***	***Section 6.4.7.1*** ***MASS.16.1***
Tensile strength, based on completely degraded waste surrogates, is felt to represent extreme, low-end tensile strengths because it does not account for several strengthening mechanisms	***DRSPALL***	***Section 6.4.7.1*** ***MASS.16.1***
Shape factor is 0.1, corresponding to particles that are easier to fluidize and entrain in the flow	***DRSPALL***	***Section 6.4.7.1*** ***MASS.16.1***
Retardation is assumed to not occur in the Salado.	NUTS CCDFGF	Section 6.4.5.4.2
Depletion of actinides in parts of the repository that have been penetrated by boreholes is not accounted for in calculating the releases from subsequent intrusions at such locations.	CUTTINGS_S	Section 6.4.13.7
Hydraulically-significant fractures are assumed to be present everywhere in the Culebra.	SECOTP2D	Section 6.4.6.2.1

REFERENCES

Andersson, J., Ed. 1989. *The Joint SKI/SKB Scenario Development Project*. SKB Technical Report 89-35, Authors: J. Andersson, T. Carlsson, T. Eng, F. Kautsky, E. Söderman, and S. Wingefors. Swedish Nuclear Fuel and Waste Management Co., Stockholm, Sweden.

Barr, G.E., Miller, W.B., and Gonzalez, D.D. 1983. *Interim Report on the Modeling of the Regional Hydraulics of the Rustler Formation.* SAND83-0391. Sandia National Laboratories, Albuquerque, NM, pp. 26 – 27. WPO 27557.

Beauheim, R.L. 1987. *Interpretations of Single-Well Hydraulic Tests Conducted At and Near the Waste Isolation Pilot Plant (WIPP) Site, 1983 – 1987*. SAND87-0039. Sandia National Laboratories, Albuquerque, NM, pp. 110 – 118. WPO 27679.

Beauheim, R.L., 1997. "Revision to Castile Brine Reservoir Parameter Packages," Memorandum to Palmer Vaughn, January 16, 1997. Sandia National Laboratories, Albuquerque, NM. WPO# 44699.

Beauheim, R.L. 2000. "Appendix E: Summary of Hydraulic Tests Performed at Tracer-Test Sites." In Interpretations of Tracer Tests Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant. L.C. Meigs, R.L. Beauheim, and T.L. Jones, eds. SAND97-3109. Sandia National Laboratories, Albuquerque, NM.

Beauheim, R.L. 2003. "Culebra and Magenta Pressures to Use in CRA BRAGFLO Runs." Memorandum to David Kessel, August 19, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS 530903.

Beauheim, R.L., Wawerisk, W.R., and Roberts, R.M. 1993. "Coupled Permeability and Hydrofracture Tests to Assess the Waste-Containment Properties of Fractured Anhydrite." *International Journal of Rock Mechanics and Mining Sciences & Geomechanical Abstracts*, Vol. 30, No. 7, pp. 1159 – 1163.

Brush, L.H., and Y. Xiong. 2003a. "Calculation of Actinide Solubilities for the WIPP Compliance Recertification Application, Analysis Plan AP-098," Rev 1. Unpublished analysis plan. Carlsbad, NM: Sandia National Laboratories. ERMS 527714.

Brush, L.H., and Y. Xiong. 2003b. "Calculation of Actinide Solubilities for the WIPP Compliance Recertification Application." Unpublished analysis report, May 8, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS 529131.

Butcher, B.M. 1996. Memo to M.S. Tierney, RE: QAP 9-1 Documentation of the Initial Waste Water Content for the CCA, January 29, 1996. WPO 30925.

Butcher, B.M., and Mendenhall, F.T., 1992. A Summary of the Models Used for the Mechanical Response of Disposal Rooms in the Waste Isolation Pilot Plant with Regards to Compliance with 40 CFR 191, Subpart B, SAND92-0427. Sandia National Laboratories. Albuquerque, NM.

Butcher, B.M., Thompson, T.W., VanBuskirk, R.G., and Patti, N.C. 1991. *Mechanical Compaction of Waste Isolation Pilot Plant Simulated Waste*. SAND90-1206. Sandia National Laboratories, Albuquerque, NM. WPO 23968.

Christian-Frear, G.L., and Webb, S.W. 1996. *The Effect of Explicit Representation of the Stratigraphy on Brine and Gas Flow at the Waste Isolation Pilot Plant*. SAND94-3173. Sandia National Laboratories, Albuquerque, NM.

Corbet, T.F. and Knupp, P.M. 1996. *The Role of Regional Groundwater Flow in the Hydrogeology of the Culebra Member of the Rustler Formation at the Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico*. SAND96-2133. ***Sandia National Laboratories***. Albuquerque, NM. ~~Sandia National Laboratories.~~

Cranwell, R.M., Guzowski, R.V., Campbell, J.E., and Ortiz, N.R. 1990. *Risk Methodology for Geologic Disposal of Radioactive Waste: Scenario Selection Procedure*. NUREG/CR-1667, SAND80-1429. Sandia National Laboratories, Albuquerque, NM. WPO 26750.

~~Dale, T., and Hurtado, L.D. 1996. "WIPP Air-Intake Shaft Disturbed-Rock Zone Study," *4th International Conference on the Mechanical Behavior of Salt, Montreal, Quebec, June 17–18, 1996*. SAND96-1327C. Albuquerque, NM: Sandia National Laboratories.~~

Davies, P.B. 1991. *Evaluation of the Role of Threshold Pressure in Controlling Flow of Waste-Generated Gas into Bedded Salt at the Waste Isolation Pilot Plant*. SAND90-3246. Sandia National Laboratories, Albuquerque, NM, pp. 17 – 19. WPO 26169.

~~Dotson, L.J. 1996. *Non-Salado Initial Pressure*. Sandia National Laboratories, NM. WPO 30713.~~

Downes, P.S. 2003a. "Spreadsheet Calculations of Actinide Solubilities for the WIPP Compliance Recertification Application." Unpublished memorandum to L.H. Brush, April 21, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS 528395.

Downes, P.S. 2003b. "Spreadsheet Calculations of Actinide Solubilities for the WIPP Compliance Recertification Application in Support of AP-098, 'Calculation of Actinide Solubilities for the WIPP Compliance Recertification Application, Analysis Plan AP-098, Rev. 1.'" Unpublished analysis report, July 22, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS 530441.

~~Earth Technology Corporation. 1988. *Final Report for Time Domain Electromagnetic (TDEM) Surveys at the WIPP Site*. SAND87-7144. Albuquerque, NM: Sandia National Laboratories.~~

Freeze, G.A., Larson, K.W., and Davies, P.B. 1995. *A Summary of Methods for Approximating Salt Creep and Disposal Room Closure in Numerical Models of Multiphase Flow*. SAND94-0251. Sandia National Laboratories, Albuquerque, NM. WPO 29557.

Goodwin, B.W., Stephens, M.E., Davison, C.C., Johnson, L.H., and Zach, R. 1994. *Scenario Analysis for the Postclosure Assessment of the Canadian Concept for Nuclear Fuel Waste Disposal*. AECL-10969, COG-94-247. Whiteshell Laboratories, Pinawa, Manitoba, Canada.

Helton, J.C., Bean, J.E., Berglund, J.W., Davies, F.J., Economy, K., Garner, J.W., Johnson, J.D., MacKinnon, R.J., Miller, J., O'Brien, D.G., Ramsey, J.L., Schreiber, J.D., Shinta, A., Smith, L.N., Stoelzel, D.M., Stockman, C., and Vaughn, P. 1998. "Uncertainty and Sensitivity Analysis Results Obtained in the 1996 Performance Assessment for the Waste Isolation Pilot Plant," SAND98-0365. Albuquerque, NM: Sandia National Laboratories. ERMS 252619.

Hobart, D.E., and Moore, R.C., 1996. Analysis of Uranium(VI) Solubility Data for WIPP Performance Assessment: Implementation of Analysis Plan AP-028, Revision 0, Aug 12, 1996. Albuquerque, NM: Sandia National Laboratories. ERMS 236488.

Hodgkinson, D.P. and Sumerling, T.J. 1989. "A Review of Approaches to Scenario Analysis for Repository Safety Assessment." In *Proceedings of the IAEA/CEC/NEA (OECD) Symposium on Safety Assessment of Radioactive Waste Repositories* (Paris, 1989). OECD/NEA, Paris, France. pp. 333 – 350.

Holt, R.M. 1997. Conceptual Model for Transport Processes in the Culebra Dolomite Member, Rustler Formation. SAND97-0194. Sandia National Laboratories, Albuquerque, NM.

Holt, R.M., and Powers, D.W. 1984. Geotechnical Activities in the Waste Handling Shaft Waste Isolation Pilot Plant (WIPP) Project Southeastern New Mexico. WTSD-TME-038. U.S. Department of Energy, Carlsbad, NM.

Holt, R.M., and Powers, D.W. 1986. Geotechnical Activities in the Exhaust Shaft. DOE/WIPP-86-008. U.S. Department of Energy, Carlsbad, NM.

Holt, R.M., and Powers, D.W. 1990. Geologic Mapping of the Air Intake Shaft at the Waste Isolation Pilot Plant. DOE/WIPP 90-051. Westinghouse Electric Corporation, Carlsbad, NM.

IAEA (International Atomic Energy Agency). 1981. Safety Assessment for the Underground Disposal of Radioactive Wastes. IAEA Safety Series No. 56, Vienna, Austria.

~~Iman, R.L., 1982. "Statistical Methods for Including Uncertainties Associated with the Geologic Isolation of Radioactive Waste Which Allow for a Comparison with Licensing Criteria," Proceedings of the Symposium on Uncertainties Associated with the Regulation of the Geologic Disposal of High-Level Radioactive Waste, Gatlinsburg, Tennessee, March 9-13, 1981, ed. D.C. Kocher. NUREG/CP-0022, CONF810372. Oak Ridge National Laboratory, Oak Ridge, Tennessee, 145-157. Available from NTIS. Order #: DE82008883.~~

Iman, R.L., and Conover, W.J. 1982. A Distribution-Free Approach to Inducing Rank Correlation Among Input Variables. Communications in Statistics: Simulation and Computation, Vol. B11, No. 3, pp. 311 – 334.

Kaplan, S., and Garrick, B.J. 1981. On the Quantitative Definition of Risk. Risk Analysis, Vol. 1, No. 1, pp. 11 – 27.

La Venue, A.M., Cauffman, T.L., and Pickens, J.F. 1990. Ground-Water Flow Modeling of the Culebra Dolomite: Volume 1 - Model Calibration. SAND89-7068/1, Sandia National Laboratories. Albuquerque, NM.

Lappin, A.R., Hunter, R.L., Garber, D.P., Davies, P.B., Beauheim, R.L., Borns, D.J., Brush, L.H., Butcher, B.M., Cauffman, T., Chu, M.S.Y., Gomez, L.S., Guzowski, R.V., Iuzzolino, H.J., Kelley, V., Lambert, S.J., Marietta, M.G., Mercer, J.W., Nowak, E.J., Pickens, J., Rechard, R.P., Reeves, M., Robinson, K.L., and Siegel, M.D., eds. 1989. Systems Analysis, Long-Term Radionuclide Transport, and Dose Assessments, Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico: March 1989. SAND89-0462. Sandia National Laboratories, Albuquerque, NM. WPO 24125.

Luker, R.S., Thompson, T.W., and Butcher, B.M. 1991. "Compaction and Permeability of Simulated Waste." In Rock Mechanics as a Multidisciplinary Science: Proceedings of the 32nd U.S. Symposium, University of Oklahoma, Norman, OK, July 10-12, 1991, J.C. Roegiers, ed. SAND90-2368C, pp. 694 – 702. A.A. Balkema, Brookfield, VT. WPO 38847.

Marcinowski, F. 2001. Untitled from F. Marcinowski to I.R. Triay, January 11, 2001. Washington, DC: U.S. Environmental Protection Agency Radiation Protection Division.

Meigs, L.C., Beauheim, R.L., and Jones, T.L., Ed. 2000. Interpretations of Tracer Tests Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant Site. SAND97-3109. Sandia National Laboratories, Albuquerque, NM.

Meigs, L.C., and McCord, J.T. 1996. "Appendix A: Physical Transport in the Culebra Dolomite." In Analysis Package for the Culebra Flow and Transport Calculations (Task 3) of the Performance Assessment Analyses Supporting the Compliance Certification Application, Analysis Plan 019, Version 00. J. Ramsey, M. Wallace, and H.-N. Jow. ERMS# 240516. Sandia National Laboratories, Albuquerque, NM.

Mercer, J.W., and Orr, B.R. 1979. *Interim Data Report on Geohydrology of Proposed Waste Isolation Pilot Plant Site, Southeast New Mexico*. Water Resources Investigations 79-98. U.S. Geological Survey, Albuquerque, NM.

Miller, W.M. and Chapman, N.A., Ed. 1992. *Identification of Relevant Processes, System Concept Group Report,* UKDOE/HMIP Report TR-ZI-11, London, England.

NAGRA. 1985. *Nuclear Waste Management in Switzerland: Feasibility Studies and Safety Analyses (Project Gewahr, 1985)*. NAGRA Project Report NGB 85-09 (English Summary), Wettingen, Switzerland.

Novak, C.F., R.C. Moore, and R.V. Bynum. 1996. "Prediction of Dissolved Actinide Concentrations in Concentrated Electrolyte Solutions: A Conceptual Model and Model Results for the Waste Isolation Pilot Plant (WIPP)." Unpublished presentation at the 1996 International Conference on Deep Geological Disposal of Radioactive Waste, September 16-19, 1996, Winnipeg, Manitoba, Canada. ERMS 418098, SAND96-2695C

OECD Nuclear Energy Agency. 1992. *Systematic Approaches to Scenario Development.* Organisation for Economic Co-Operation and Development, Paris, France. NWM Library, NNA.920610.0027.

Park, B,Y,. and J.F., Holland. 2003. "Structual Evaluation of WIPP Disposal Room Raised to Clay G." SAND2003-3409, Sandia National Laboratories. Carlsbad, NM.

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. *Brine Reservoirs in the Castile Formation Waste Isolation Pilot Plant (WIPP) Project Southeastern New Mexico.* TME-3153, ~~Vols. 1 and 2.~~ Westinghouse Electric Corp, Carlsbad, NM.

Sandia National Laboratories. 1991. *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume. 1: Methodology and Results.* SAND91-0893/1. Sandia National Laboratories, WIPP Performance Assessment Division, Albuquerque, NM. WPO 26404.

Sandia National Laboratories. 1992-1993. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992.* SAND92-0700, Vols. 1 – 5. Sandia National Laboratories, WIPP Performance Assessment Division, Albuquerque, NM. Vol. 1 - WPO 20762, Vol. 2 - WPO 20805, Vol. 3 - WPO 23529, Vol. 4 - WPO 20958, Vol. 5 - WPO 20929.

Sandia National Laboratories. 2003. Borehole Plugging Probabilities to be used in Compliance Recertification Calculations. September 3, 2003. Sandia Records Center, Sandia National Laboratories, Carlsbad Programs Group. Carlsbad, NM. ERMS# 531352.

State of New Mexico, Oil Conservation Division, Energy, Minerals, and Natural Resources Department. 1988. "Application of the Oil Conservation Division Upon It's Own Motion to Revise Order R-111, As Amended, Pertaining to the Potash Areas of Eddy and Lea Counties, New Mexico." Case 9316, Revision to Order R-111-P, April 21, 1988. Santa Fe, NM. On file in the NWM Library as KFN2581.

Stenhouse, M.J., Chapman, N.A., and Sumerling, T.J. 1993. *SITE-94 Scenario Development FEP Audit List Preparation: Methodology and Presentation*. SKI Technical Report 93:27. Swedish Nuclear Power Inspectorate, Stockholm. Available from NTIS as DE 94621513.

Thorne, M.C. 1992. *Dry Run 3 - A Trial Assessment of Underground Disposal of Radioactive Wastes Based on Probabilistic Risk Analysis - Volume 8: Uncertainty and Bias Audit.* United Kingdom Department of Environment Report DOE/HMIP/RR/92.040, London, England.

Trovato, E.R. 1997. Untitled letter from E.R. Trovato to G. Dials, April 25, 1997. Washington, DC: U.S. Environmental Protection Agency Office of Radiation and Indoor Air.

U.S. Environmental Protection Agency (EPA). 1998a. "40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the Disposal Regulations "Certification Decision; Final Rule." Federal Register, Vol. 63, No. 95, pp. 27396, May 18, 1998. Office of Radiation and Indoor Air, Washington D.C.

U.S. Environmental Protection Agency (EPA). 1998b. "Technical Support Document for Section 194.23: Parameter Justification Report." EPA Air Docket A93-02-V-B-14. Washington, DC: U.S. Environmental Protection Agency Office of Radiation and Indoor Air.

U.S. Environmental Protection Agency (EPA). 1998c. "Compliance Application Review Documents for the Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations: Final Certification Decision. CARD 23: Models and Computer Codes." EPA Air Docket A93-02-V-B-2. Washington, DC: U.S. Environmental Protection Agency Office of Radiation and Indoor Air.

U.S. Environmental Protection Agency (EPA). 1998d. "Technical Support Document for Section 194.23 - Models and Computer Codes." EPA Air Docket A93-02-V-B-6. Washington, DC: U.S. Environmental Protection Agency Office of Radiation and Indoor Air.

U.S. Environmental Protection Agency (EPA). 1985. "40 CFR Part 191: Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule." *Federal Register,* Vol. 50, No. 182, pp. 38066 – 38089, September 19, 1985. Office of Radiation and Air, Washington, D.C. WPO 39132.

U.S. Environmental Protection Agency (EPA). 1993. "40 CFR Part 191: Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule." *Federal Register,* Vol. 48, No. 242, pp. 66398 – 66416, December 20, 1993. Office of Radiation and Air, Washington, D.C. WPO 39133.

U.S. Environmental Protection Agency (EPA). 1996a. "40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations Final Rule." *Federal Register*, Vol. 61, No. 28, pp. 5224 – 5245, February 9, 1996. Office of Radiation and Indoor Air, Washington, D.C. In NWM Library as KF70.A35.C751 1996 (Reference)

U.S. Environmental Protection Agency (EPA). 1996b. *Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations. Background Information Document for 40 CFR Part 194.* EPA 402-R-96-002. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, DC.

~~Van Pelt, R.S. November 20, 1995. "Permeability Estimates of MGFT08 and MGFT09." SNL Technical Memorandum to M.K. Knowles. Contained in SWCF Record Package, "Small-Scale Seals Performance Test: Series A Post-Mortem," WPO 39631.~~

Vaughn, P., Bean, J., Garner, J., Lord, M., MacKinnon, R., McArthur, D., Schreiber, J., and Shinta, A.. 1995. *FEPs Screening Analysis DR2, DR3, DR6, DR7, and S6*. Record package submitted to SWCF-A:1.1.6.3:PA:QA:TSK:DR2, DR3, DR6, DR7, and S6. Sandia National Laboratories, Albuquerque, NM. WPO 38152.

Wallace, M.G., Beauheim, R., Stockman, C., Martell, M.A., Brinster, K., Wilmot, R., and Corbet, T. 1995. *FEPs Screening Analysis, NS-1: Dewey Lake Data Collection and*

Compilation. Record package submitted to SWCF-A:1.1.6.3:PA:QA:TSK:NS1. Sandia National Laboratories, Albuquerque, NM. WPO 30650.

~~Wang, Y., and Brush, L.H. January 26, 1996. "Estimates of Gas Generation Parameters for the Long-Term WIPP Performance Assessment." WPO 31943.~~

INDEX

40 CFR Part 191 ..... *6-3, 6-14, 6-15, 6-16, 6-34, 6-41, 6-46, 6-50, 6-52, 6-161, 6-186*
40 CFR Part 194 ..... *6-3, 6-15, 6-34, 6-53, 6-54, 6-121, 6-123, 6-161, 6-183*
accessible environment *6-3, 6-6, 6-7, 6-9, 6-15, 6-16, 6-27, 6-58, 6-64, 6-66, 6-70, 6-73, 6-75, 6-87, 6-99, 6-106, 6-109, 6-110, 6-116, 6-123, 6-130, 6-131, 6-132, 6-157, 6-159, 6-160, 6-168, 6-172, 6-174, 6-175, 6-180, 6-182, 6-184, 6-185, 6-186, 6-187, 6-188*
actinide *6-2, 6-6, 6-9, 6-10, 6-11, 6-12, 6-73, 6-79, 6-80, 6-88, 6-91, 6-92, 6-94, 6-95, 6-96, 6-97, 6-109, 6-110, 6-117, 6-118, 6-131, 6-135, 6-172, 6-174, 6-178, 6-181, 6-192, 6-193, 6-194*
- *chemistry* *6-93*
- *colloidal* *6-6, 6-11, 6-66, 6-80, 6-88, 6-96, 6-97, 6-98, 6-107, 6-121*
- *colloids* *6-58*
- *compounds* *6-95*
- *concentration* *6-96, 6-97, 6-153, 6-154, 6-178*
- *dissolved* *6-88, 6-89, 6-95, 6-110, 6-115, 6-118, 6-120*
- *initial* *6-153*
- *intrinsic colloid* *6-10*
- *inventory* *6-95, 6-97*
- *mineral fragment colloidal* *6-121*
- *mobilization* *6-9*
- *oxidation states* *6-93*
- *release* *6-131*
- *Salado* *6-106*
- *solubility* *6-2, 6-10, 6-87, 6-89, 6-90, 6-91, 6-94, 6-157*
- *sorption* *6-62*
- *source* *6-154*
- *source term* *6-92, 6-96, 6-97*
- *source term - colloidal* *6-178*
- *transport* *6-7, 6-8, 6-10, 6-12, 6-70, 6-73, 6-94, 6-106, 6-107, 6-130, 6-154, 6-174, 6-176*
- *transport - Culebra* *6-12, 6-115*
- *uptake* *6-96*

active institutional controls *6-7, 6-12, 6-160, 6-161, 6-162, 6-164*
advection *6-45, 6-63, 6-107, 6-115, 6-117, 6-120, 6-160*
aggregation *6-19, 6-26, 6-29*
analysis *6-144*
- *sensitivity* *6-28*
- *uncertainty* *6-28, 6-30*

angle of draw *6-123*
anhydrite *6-6, 6-11, 6-58, 6-75, 6-80, 6-82, 6-90, 6-101, 6-102, 6-103, 6-104, 6-109, 6-142*
- *anoxic corrosion* *6-10, 6-83, 6-85, 6-86, 6-87, 6-88, 6-93*
- *rich* *6-75*

anthropogenic *6-52, 6-146, 6-148*
- *climate change* *6-50*

assurance requirements *6-161*
average stoichiometry model *6-81, 6-85, 6-87*
backfill *6-32, 6-41, 6-42, 6-44, 6-61, 6-169*

berm *6-163*
borehole *6-2, 6-3, 6-7, 6-8, 6-9, 6-10, 6-11, 6-13, 6-34, 6-47, 6-48, 6-49, 6-50, 6-51, 6-53, 6-54, 6-56, 6-59, 6-61, 6-63, 6-64, 6-65, 6-66, 6-68, 6-70, 6-74, 6-79, 6-80, 6-82, 6-88, 6-96, 6-109, 6-110, 6-111, 6-115, 6-121, 6-122, 6-131, 6-132, 6-133, 6-134, 6-135, 6-136, 6-137, 6-138, 6-139, 6-140, 6-141, 6-142, 6-151, 6-154, 6-155, 6-157, 6-159, 6-160, 6-162, 6-163, 6-165, 6-169, 6-170, 6-171, 6-174, 6-175, 6-176, 6-177, 6-178, 6-179, 6-180, 6-181, 6-191, 6-192, 6-193, 6-194*
cuttings *6-159*
intrusion *6-27*
number *6-27*
plug *6-2, 6-10, 6-138*
three-plug configuration *6-171*
time *6-27*
two-plug configuration *6-171*
uncertainty *6-27*
boundary *6-6, 6-7, 6-13, 6-16, 6-58, 6-74, 6-75, 6-106, 6-111, 6-113, 6-130, 6-152*
condition *6-81, 6-110, 6-136, 6-137, 6-149*
site *6-109*
breccia pipes *6-38, 6-56*
brine *6-9, 6-11, 6-67, 6-68, 6-80, 6-82, 6-106, 6-107, 6-108, 6-110, 6-132, 6-133, 6-138, 6-141, 6-144, 6-154, 6-180*
Castile *6-88, 6-90, 6-94, 6-95*
composition *6-88*
compressibility *6-142*
direct release *6-15*
flow *6-82*
inflow *6-5, 6-6, 6-34, 6-43, 6-62, 6-103*
long-term *6-10*
permeability *6-142*
porosity *6-142*
pressure *6-142*
repository *6-9*
reservoir *6-38, 6-66, 6-68, 6-74, 6-141, 6-142, 6-144, 6-151, 6-157, 6-163, 6-169, 6-177*
Salado *6-88, 6-90, 6-94, 6-95*
calcite *6-94*
calibrated *6-111, 6-159*
canister *6-32, 6-33, 6-164*
capillary pressure *6-84, 6-114, 6-131, 6-132, 6-133*
Castile *6-13, 6-47, 6-48, 6-49, 6-66, 6-67, 6-68, 6-90, 6-94, 6-95, 6-98, 6-133, 6-138, 6-139, 6-140, 6-141, 6-142, 6-144, 6-151, 6-157, 6-163, 6-177, 6-180*
brine *6-157*
brine reservoir *6-74, 6-88*
cavings *6-7, 6-8, 6-9, 6-13, 6-15, 6-45, 6-64, 6-65, 6-135, 6-136, 6-154, 6-159, 6-163, 6-168, 6-169, 6-179, 6-180, 6-188, 6-189, 6-192*
CDF *6-119, 6-155, 6-162, 6-163, 6-169, 6-171*
cellulosic *6-83, 6-86, 6-87*

channeling 6-107, 6-108
chemical condition 6-87, 6-96
climate 6-12, 6-60, 6-110, 6-111, 6-146, 6-147, 6-148
  change 6-40, 6-146, 6-147, 6-148, 6-149
  index 6-147, 6-148, 6-149
colloid 6-6, 6-58, 6-120
  actinide-intrinsic 6-96, 6-120
  concentration 6-97, 6-98
  filtration 6-44
  formation 6-44, 6-107
  intrinsic 6-96
  mineral-fragment 6-107
  sorption 6-44
  transport 6-44, 6-63
  types 6-96
complementary cumulative distribution function (CCDF) 6-3, 6-4, 6-13, 6-14, 6-15, 6-19, 6-20, 6-21, 6-22, 6-23, 6-24, 6-25, 6-27, 6-28, 6-29, 6-30, 6-35, 6-72, 6-106, 6-130, 6-137, 6-160, 6-172, 6-173, 6-174, 6-175, 6-177, 6-179, 6-181, 6-182, 6-183, 6-184, 6-185, 6-186, 6-187, 6-188, 6-189, 6-190, 6-191, 6-192
compliance 6-1, 6-7, 6-13, 6-14, 6-15, 6-23, 6-25, 6-26, 6-31, 6-33, 6-35, 6-36, 6-46, 6-51, 6-52, 6-53, 6-54, 6-55, 6-58, 6-59, 6-138, 6-162, 6-173, 6-183, 6-186, 6-191, 6-192
  assessment 6-26, 6-41, 6-46, 6-50, 6-51, 6-52, 6-56
components 6-88
computational model 6-28, 6-72, 6-73, 6-191
computer codes 6-27, 6-72, 6-73, 6-149, 6-154, 6-177
  BRAGFLO 6-73, 6-74, 6-75, 6-76, 6-77, 6-78, 6-79, 6-81, 6-83, 6-85, 6-97, 6-99, 6-102, 6-103, 6-106, 6-108, 6-109, 6-111, 6-114, 6-130, 6-132, 6-133, 6-135, 6-136, 6-137, 6-138, 6-139, 6-140, 6-141, 6-142, 6-144, 6-146, 6-149, 6-150, 6-151, 6-153, 6-154, 6-155, 6-157, 6-159, 6-171, 6-172, 6-174, 6-175, 6-176, 6-177, 6-178, 6-179, 6-180, 6-191, 6-193, 6-194
  CCDFGF 6-160, 6-193, 6-194
  CUTTINGS_S ... 6-135, 6-136, 6-139, 6-153, 6-154, 6-155, 6-157, 6-159, 6-169, 6-174, 6-179, 6-180, 6-193, 6-194
  DRSPALL 6-135, 6-155, 6-157, 6-194
  MODFLOW-2 6-111
  MODFLOW-2000 ..... 6-73, 6-109, 6-113, 6-115, 6-118, 6-152, 6-153, 6-155, 6-157, 6-159
  NUTS 6-95, 6-106, 6-107, 6-153, 6-154, 6-155, 6-157, 6-160, 6-172, 6-174, 6-175, 6-176, 6-193, 6-194
  PANEL 6-135, 6-153, 6-154, 6-155, 6-157, 6-160, 6-178, 6-193, 6-194
  PEST 6-155, 6-157
  SANTOS 6-81, 6-155, 6-157
  SECOFL2D 6-193
  SECOTP2D 6-73, 6-109, 6-113, 6-115, 6-119, 6-147, 6-152, 6-153, 6-155, 6-159, 6-174, 6-176, 6-194
concentration 6-96, 6-97
conceptual model 6-3, 6-6, 6-9, 6-26, 6-28, 6-31, 6-57, 6-59, 6-72, 6-75, 6-108, 6-109, 6-110, 6-111, 6-115, 6-117, 6-118, 6-119, 6-120, 6-121, 6-123, 6-132, 6-135, 6-136, 6-141, 6-179

condition.... 6-6, 6-8, 6-10, 6-14, 6-36, 6-58, 6-68, 6-80, 6-82, 6-83, 6-85, 6-86, 6-88, 6-89, 6-91, 6-93, 6-94, 6-97, 6-101, 6-111, 6-135, 6-137, 6-138, 6-151, 6-152, 6-178, 6-180, 6-182
boundary.....6-73, 6-149, 6-151, 6-153, 6-154
chemical..... 6-80
disturbed performance (DP)..... 6-51
homogeneous..... 6-88
initial..... 6-149, 6-150, 6-153, 6-180
initial pressure.....6-151, 6-157
undisturbed performance (UP)..... 6-44, 6-51, 6-74
consequence analysis..... 6-1, 6-26, 6-55, 6-66, 6-68, 6-69, 6-72, 6-121, 6-180
conservative assumptions..... 6-9, 6-191, 6-192
continuous plug.....6-138, 6-139
contribution to uncertainty..... 6-182
control berms..... 6-163
controlled area..... 6-7, 6-11, 6-12, 6-13, 6-16, 6-46, 6-47, 6-49, 6-50, 6-51, 6-52, 6-53, 6-54, 6-55, 6-57, 6-59, 6-66, 6-71, 6-73, 6-111, 6-121, 6-123, 6-128, 6-129, 6-130, 6-149, 6-161, 6-172
creep closure..... 6-5, 6-73, 6-80, 6-81, 6-82, 6-84, 6-99, 6-105, 6-140
Culebra.....6-2, 6-8, 6-11, 6-12, 6-44, 6-58, 6-59, 6-66, 6-71, 6-75, 6-82, 6-97, 6-108, 6-109, 6-110, 6-111, 6-112, 6-113, 6-114, 6-115, 6-116, 6-117, 6-118, 6-119, 6-120, 6-123, 6-128, 6-129, 6-130, 6-131, 6-147, 6-149, 6-150, 6-151, 6-152, 6-153, 6-154, 6-155, 6-157, 6-159, 6-172, 6-174, 6-176, 6-177, 6-178, 6-179, 6-181, 6-192, 6-193, 6-194
actinides..... 6-70
colloidal actinide transport..... 6-120
dissolved actinides..... 6-119
transmissivity..... 6-59
cuttings.....6-7, 6-8, 6-9, 6-13, 6-15, 6-45, 6-64, 6-65, 6-133, 6-134, 6-135, 6-136, 6-154, 6-163, 6-168, 6-169, 6-179, 6-180, 6-182, 6-188, 6-189, 6-192
decommissioning..... 6-162
deep drilling..... 6-46, 6-53, 6-54, 6-55, 6-57, 6-59, 6-64, 6-66, 6-68, 6-69, 6-70, 6-71, 6-161
deformation.....6-4, 6-13, 6-38, 6-73, 6-98
degradation..... 6-4, 6-5, 6-11, 6-42, 6-43, 6-44, 6-61, 6-62, 6-80, 6-86, 6-96, 6-140
Delaware Basin..... 6-7, 6-8, 6-9, 6-10, 6-11, 6-13, 6-37, 6-53, 6-54, 6-59, 6-66, 6-121, 6-123, 6-135, 6-138, 6-139, 6-142, 6-161, 6-162, 6-169
deliberate intrusion..... 6-55
Dewey Lake..... 6-44, 6-108, 6-131, 6-132, 6-133, 6-150
diameter..... 6-169
diapirism..... 6-38
diffusion.....6-12, 6-45, 6-63, 6-108, 6-110, 6-117, 6-118, 6-119, 6-120, 6-154, 6-160
dilation..... 6-107
direct brine release (DBR)... 6-7, 6-132, 6-135, 6-136, 6-137, 6-138, 6-153, 6-154, 6-155, 6-159, 6-163, 6-164, 6-166, 6-180, 6-182, 6-189
discharge.....6-12, 6-40, 6-60, 6-147, 6-149
areas..... 6-147
discretizing..... 6-163
dispersion..... 6-107, 6-117, 6-120, 6-154

disposal system *6-2, 6-3, 6-4, 6-6, 6-7, 6-11, 6-14, 6-15, 6-16, 6-23, 6-26, 6-29, 6-31, 6-32, 6-35, 6-36, 6-37, 6-46, 6-51, 6-52, 6-53, 6-55, 6-56, 6-57, 6-58, 6-72, 6-73, 6-74, 6-82, 6-84, 6-106, 6-108, 6-111, 6-121, 6-122, 6-123, 6-128, 6-129, 6-132, 6-136, 6-149, 6-151, 6-154, 6-155, 6-157, 6-158, 6-161, 6-177, 6-191, 6-192*
condition *6-154*
geometry *6-141, 6-144*
performance ... *6-1, 6-14, 6-15, 6-26, 6-31, 6-32, 6-37, 6-51, 6-52, 6-141, 6-146, 6-147, 6-155, 6-161, 6-179, 6-182, 6-183*
units *6-121*
dissolution *6-38, 6-39, 6-43, 6-44, 6-56, 6-58, 6-60, 6-62, 6-90, 6-95, 6-107, 6-134, 6-191, 6-193*
dissolved actinides *6-96*
disturbed mining *6-129, 6-130*
disturbed performance (DP) *6-7, 6-12, 6-34, 6-35, 6-41, 6-46, 6-58, 6-59, 6-65, 6-66, 6-67, 6-69, 6-70, 6-71, 6-129, 6-154, 6-173, 6-181*
disturbed rock zone (DRZ) *6-2, 6-4, 6-5, 6-6, 6-42, 6-58, 6-61, 6-82, 6-98, 6-99, 6-101, 6-102, 6-103, 6-104, 6-105, 6-136, 6-150, 6-151, 6-152, 6-193*
permeability *6-98, 6-136, 6-150*
shaft *6-98*
dose *6-36*
double-porosity *6-110, 6-160*
drainage *6-150, 6-151*
drilling *6-3, 6-7, 6-8, 6-9, 6-13, 6-27, 6-47, 6-48, 6-51, 6-52, 6-53, 6-54, 6-57, 6-59, 6-63, 6-65, 6-66, 6-67, 6-68, 6-69, 6-84, 6-111, 6-132, 6-133, 6-134, 6-135, 6-136, 6-138, 6-140, 6-159, 6-160, 6-161, 6-162, 6-163, 6-169, 6-171, 6-172, 6-174, 6-178, 6-179, 6-180, 6-181, 6-192*
activities *6-46*
deep *6-59*
fluid *6-8, 6-48, 6-59, 6-154, 6-159*
rate *6-2, 6-53, 6-162*
scenario *6-59*
E1 scenario *6-68, 6-95, 6-156, 6-157, 6-172, 6-174, 6-175, 6-177*
E1E2 scenario .. *6-65, 6-68, 6-95, 6-136, 6-154, 6-156, 6-157, 6-172, 6-177, 6-178, 6-192, 6-193*
E2 scenario *6-68, 6-69, 6-88, 6-95, 6-156, 6-172, 6-175, 6-176, 6-177, 6-178*
engineered barrier *6-55*
erosion *6-39*
event
E1 ..... *6-74*
E1E2 ..... *6-74*
E2 ..... *6-74*
events and processes (EPs)
disruptive *6-56*
human-initiated *6-46, 6-48, 6-50, 6-52, 6-55, 6-58, 6-65*
facility design *6-3*
farming *6-50*
fault *6-38*

features, events, and processes (FEPs) ... 6-1, 6-2, 6-14, 6-26, 6-31, 6-32, 6-33, 6-34, 6-35, 6-44, 6-55, 6-56, 6-57, 6-59, 6-60, 6-65, 6-66, 6-67
climate ... 6-40
natural ... 6-36, 6-37, 6-38, 6-60, 6-65
radiological ... 6-41
SKI list ... 6-32
waste- and repository-induced ... 6-36, 6-37, 6-41, 6-46, 6-57, 6-61, 6-65
WIPP ... 6-32
filtration ... 6-120
fingering ... 6-107
fluvial ... 6-39, 6-40
Forty-niner ... 6-108, 6-130, 6-193
fracture ... 6-5, 6-11, 6-12, 6-38, 6-58, 6-103, 6-107, 6-108, 6-115, 6-117, 6-120, 6-142, 6-160, 6-192, 6-194
Fracture-Matrix Transport (FMT) ... 6-91, 6-94, 6-157
future events ... 6-20, 6-29, 6-155, 6-160, 6-172, 6-178, 6-181
future human activities ... 6-29
gas generation ... 6-5, 6-6, 6-43, 6-57, 6-58, 6-62, 6-73, 6-80, 6-81, 6-82, 6-83, 6-84, 6-85, 6-86, 6-87, 6-99
model ... 6-83
rates ... 6-85
generator sites ... 6-164
geological structure analysis ... 6-169
geometry
disposal system ... 6-74
glaciation ... 6-40, 6-146
groundwater ... 6-7, 6-8, 6-10, 6-11, 6-12, 6-36, 6-38, 6-39, 6-47, 6-48, 6-49, 6-51, 6-56, 6-60, 6-63, 6-66, 6-73, 6-75, 6-109, 6-110, 6-112, 6-115, 6-120, 6-123, 6-138, 6-146, 6-147, 6-148, 6-149, 6-152, 6-153, 6-189
half-lives ... 6-16
human activities
current ... 6-51, 6-52
future ... 6-51, 6-52
historical ... 6-51, 6-52
near-future ... 6-51, 6-52
human intrusion ... 6-3, 6-4, 6-7, 6-14, 6-46, 6-55, 6-56, 6-57, 6-79, 6-93, 6-111, 6-132, 6-161
inadvertent ... 6-2, 6-3
hydraulic
conductivity ... 6-53, 6-121, 6-123
testing ... 6-117
hydrostatic ... 6-8, 6-9, 6-66, 6-132, 6-133, 6-150
infiltration ... 6-40, 6-60
initial pressure ... 6-131, 6-132, 6-133, 6-142, 6-150, 6-151
interbed ... 6-6, 6-58, 6-75, 6-82, 6-101, 6-102, 6-103, 6-104, 6-107, 6-108, 6-174, 6-175
anhydrite ... 6-107
dilation ... 6-103

fracturing *6-103*
Salado *6-104, 6-107*
intrusion
borehole *6-108*
diameter *6-169*
inadvertent human *6-68, 6-108, 6-132, 6-159, 6-161, 6-162, 6-192*
location *6-163*
karst *6-11*
K_ds *6-12, 6-118, 6-119*
Land Withdrawal Act (LWA) *6-1, 6-16*
Land Withdrawal Area *6-171, 6-181*
Latin Hypercube Sampling (LHS) *6-22, 6-28, 6-29, 6-83, 6-94, 6-95, 6-119, 6-129, 6-147, 6-150, 6-154, 6-155, 6-156, 6-157, 6-172, 6-181, 6-182, 6-183*
loading *6-80, 6-81, 6-168*
long-term brine release *6-7*
Los Medaños *6-109, 6-130, 6-140, 6-193*
Magenta *6-108, 6-130, 6-131, 6-151*
mathematical model *6-28, 6-72, 6-73, 6-81, 6-109, 6-123*
McNutt Potash Zone *6-11, 6-128, 6-129*
metamorphic *6-38*
microbial colloids *6-98*
microbial degradation *6-6*
mining *6-122*
disturbed performance (DP) *6-69*
multiplier *6-128*
probability *6-171*
scenario *6-59, 6-67*
model *6-146*
climate change *6-147*
computational *6-1, 6-153*
conceptual *6-1, 6-3, 6-72*
disposal system flow and transport *6-150*
gas generation *6-85, 6-152*
geometry *6-73, 6-79*
mathematical *6-72, 6-149*
multimechanism deformation *6-80*
numerical *6-73*
repository flow *6-83*
modeling system *6-14, 6-31, 6-58, 6-68, 6-72, 6-73, 6-74, 6-107, 6-160, 6-191*
Monte Carlo analysis *6-28, 6-31, 6-182, 6-183*
mudstone *6-11*
multimechanism deformation model *6-81*
multiple replication *6-183*
Nash Draw *6-152*
oil and gas
exploration *6-47, 6-65*

organic complexation 6-44, 6-56, 6-62
organic ligands 6-2, 6-44, 6-55, 6-56, 6-62, 6-91
oxidation state 6-9, 6-10, 6-88, 6-89, 6-93
parameter ..... 6-8, 6-9, 6-12, 6-14, 6-23, 6-27, 6-29, 6-72, 6-73, 6-87, 6-92, 6-98, 6-99, 6-102, 6-104 , 6-105, 6-114, 6-118, 6-119, 6-120, 6-123, 6-130, 6-131, 6-132, 6-133, 6-139, 6-141, 6-142, 6-144, 6-146, 6-147, 6-148, 6-149, 6-150, 6-152, 6-155, 6-157, 6-182
  database 6-99, 6-155
  value 6-142, 6-155, 6-169
passive institutional controls 6-2, 6-7, 6-15, 6-160, 6-161
performance assessment (PA) 6-1, 6-3, 6-7, 6-14, 6-15, 6-23, 6-31, 6-46, 6-53, 6-88, 6-121, 6-123, 6-154, 6-160, 6-161, 6-182, 6-191
permafrost 6-40
permeability 6-79, 6-104
  DRZ 6-105
plugging 6-34, 6-138, 6-139
Poisson model 6-162, 6-171
porosity
  advective 6-119
  fracture 6-104
  surface 6-81, 6-82, 6-84
possible futures 6-25, 6-182
potash 6-121
precipitation 6-40, 6-43, 6-44, 6-60, 6-62, 6-107
preliminary analysis 6-179
pressure
  capillary 6-100, 6-105
  fracture initiation 6-104
  maximum capillary 6-104
  threshold 6-104, 6-105
pressurized brine reservoir 6-13
probabilistic analysis 6-27, 6-28
probability 6-14, 6-171
  distributions 6-20, 6-23
puddling 6-83
quality assurance (QA) 6-3, 6-14
radioactive decay 6-37, 6-41, 6-42, 6-61, 6-173, 6-180
radionuclide inventory 6-6
radionuclide transport 6-56, 6-58, 6-59
ranching 6-50
random sampling 6-27, 6-28, 6-29, 6-154, 6-155, 6-160, 6-162, 6-169, 6-172, 6-173, 6-178, 6-181
recharge 6-11, 6-40, 6-146, 6-147, 6-148
reference condition 6-130, 6-154, 6-174, 6-176, 6-179
regional analysis 6-146
regional domain 6-115, 6-123
release limits 6-16, 6-17, 6-163

repository
fluid flow *6-80*
induced flow *6-61*
response *6-80*
risk *6-17, 6-20, 6-22, 6-27*
quantification *6-17, 6-22*
representation *6-19*
uncertainty *6-19*
Rustler *6-8, 6-10, 6-11, 6-109, 6-130, 6-131, 6-135, 6-139, 6-140, 6-150, 6-177, 6-193*
Salado *6-5, 6-7, 6-8, 6-11, 6-12, 6-13, 6-53, 6-58, 6-66, 6-68, 6-75, 6-80, 6-82, 6-88, 6-90, 6-94, 6-95, 6-96, 6-98, 6-99, 6-101, 6-102, 6-103, 6-105, 6-106, 6-107, 6-108, 6-109, 6-128, 6-129, 6-135, 6-136, 6-138, 6-139, 6-142, 6-150, 6-151, 6-155, 6-174, 6-175*
interbeds *6-102*
saline *6-39*
salt creep *6-5, 6-6, 6-57, 6-58, 6-61, 6-80, 6-98, 6-99*
scaling *6-12, 6-29, 6-73, 6-147, 6-149, 6-172, 6-173, 6-174, 6-176, 6-177, 6-179, 6-181*
scenario *6-1, 6-7, 6-13, 6-19, 6-20, 6-25, 6-26, 6-27, 6-28, 6-31, 6-55, 6-59, 6-70, 6-72, 6-87, 6-157, 6-179, 6-180*
analysis *6-57*
consequences *6-72*
deep drilling *6-69*
E1 ..... *6-88*
E1E2 ..... *6-88*
human intrusion *6-55*
screened out-consequence (SO-C) *6-34, 6-35, 6-38, 6-39, 6-40, 6-41, 6-42, 6-43, 6-44, 6-45, 6-46, 6-47, 6-48, 6-49, 6-50, 6-56*
screened out-probability (SO-P) *6-34, 6-35, 6-38, 6-39, 6-40, 6-42, 6-44, 6-46, 6-50, 6-56*
screened out-regulation (SO-R) *6-34, 6-35, 6-45, 6-46, 6-47, 6-48, 6-49, 6-50, 6-56*
seals *6-42, 6-44, 6-58, 6-59, 6-61, 6-62*
sensitivity analysis *6-31*
shaft
seals *6-37, 6-97, 6-98, 6-151, 6-193*
shallow drilling *6-53, 6-54, 6-55*
siltstone *6-109*
single porosity *6-117*
site *6-32, 6-35, 6-111, 6-113, 6-116, 6-117, 6-130, 6-132, 6-141, 6-146, 6-152, 6-160, 6-169*
boundary *6-111*
characterization *6-3, 6-11, 6-52, 6-55, 6-191*
waste-generator *6-166*
SKI list *6-32*
Software Configuration Management System (SCMS) *6-30, 6-154, 6-155*
sorption *6-46, 6-62, 6-110, 6-117, 6-118, 6-119, 6-131, 6-191, 6-193*
actinides *6-193*
source term
actinide *6-91, 6-157, 6-160, 6-175, 6-176*
colloidal actinides *6-96, 6-98*

dissolved species (solubility) *6-91, 6-92*
mobile suspended (colloidal) species *6-91, 6-92*
spalling *6-2, 6-7, 6-8, 6-9, 6-13, 6-15, 6-45, 6-64, 6-65, 6-135, 6-136, 6-154, 6-157, 6-159, 6-164, 6-166, 6-168, 6-180, 6-188, 6-189*
stratigraphy *6-60, 6-65, 6-101, 6-116, 6-141*
subjective uncertainty *6-20*
subsidence *6-11, 6-12, 6-38, 6-42, 6-49, 6-59, 6-110, 6-111, 6-115, 6-121, 6-128*
surface *6-3, 6-8, 6-11, 6-13, 6-15, 6-40, 6-44, 6-49, 6-54, 6-56, 6-58, 6-60, 6-62, 6-63, 6-74, 6-97, 6-103, 6-107, 6-111, 6-133, 6-134, 6-135, 6-136, 6-139, 6-154, 6-157, 6-159, 6-166, 6-169, 6-172, 6-174, 6-175, 6-177, 6-179, 6-192, 6-194*
environment *6-33*
ground *6-7, 6-8, 6-9, 6-10, 6-13, 6-66, 6-108, 6-138, 6-147*
hydrology *6-60*
land *6-15, 6-146, 6-147, 6-148*
near *6-134*
porosity *6-152, 6-157*
temperature *6-146*
water *6-15, 6-50*
water-table *6-150*
Tamarisk *6-108, 6-130, 6-193*
tectonics *6-38*
thermodynamic equilibrium *6-88, 6-96*
three-plug configuration *6-140*
threshold pressure *6-82, 6-84, 6-102, 6-103, 6-114, 6-131, 6-132, 6-133, 6-139, 6-142, 6-144*
transmissivity ... *6-11, 6-12, 6-70, 6-103, 6-109, 6-110, 6-111, 6-114, 6-115, 6-118, 6-123, 6-128, 6-130, 6-159*
Culebra *6-71, 6-114, 6-157*
fields *6-117, 6-157, 6-181*
transport *6-11, 6-12, 6-40, 6-44, 6-45, 6-51, 6-58, 6-62, 6-65, 6-66, 6-70, 6-71, 6-75, 6-82, 6-93, 6-97, 6-106, 6-107, 6-109, 6-110, 6-111, 6-114, 6-115, 6-117, 6-118, 6-119, 6-120, 6-128, 6-129, 6-138, 6-149, 6-152, 6-154, 6-159, 6-174, 6-175, 6-176, 6-181, 6-189, 6-192*
actinide *6-107, 6-108, 6-109, 6-132, 6-192*
analysis *6-106*
dissolved actinide *6-12, 6-119*
filtration *6-63*
formation and stability *6-63*
groundwater *6-166, 6-189*
microbial *6-63*
pathways *6-108*
radionuclide *6-73, 6-75, 6-106, 6-107, 6-130, 6-146, 6-147, 6-149, 6-154*
sorption *6-63*
Transuranic Waste Baseline Inventory Report (TWBIR) *6-166*
two-phase flow *6-73, 6-82, 6-84, 6-136, 6-144*
two-plug configuration *6-139, 6-140*
uncertainty *6-11, 6-12, 6-14, 6-20, 6-21, 6-29, 6-30, 6-31, 6-35, 6-73, 6-85, 6-94, 6-103, 6-107, 6-114, 6-141, 6-146, 6-148, 6-149, 6-154, 6-155, 6-169, 6-172, 6-191*

aggregation *6-20*
disposal system *6-27*
risk *6-17*
stochastic *6-19, 6-20, 6-22, 6-26, 6-27, 6-28, 6-29, 6-30, 6-141, 6-160, 6-182*
subjective *6-19, 6-22, 6-27, 6-28, 6-29, 6-30, 6-141, 6-182*
underground *6-5, 6-48, 6-81*
boreholes *6-43, 6-61*
deposits *6-53*
facilities *6-47, 6-52*
undisturbed mining case *6-129*
undisturbed performance (UP) *6-4, 6-6, 6-8, 6-35, 6-41, 6-46, 6-50, 6-56, 6-60, 6-64, 6-76, 6-88 6-122, 6-128, 6-156, 6-172, 6-175, 6-177, 6-181*
scenario *6-172*
unloading *6-81, 6-98*
unnamed lower member *6-109*
uplift *6-38*
volatile organic compound (VOC) *6-34*
volumetric plasticity model *6-81*
vug *6-12, 6-117*
waste
activity *6-8*
characterization *6-3, 6-9, 6-41, 6-61, 6-65, 6-191*
disposal region *6-67, 6-79*
inventory *6-41, 6-61, 6-83, 6-163, 6-166*
permeability *6-2, 6-83*
unit factor *6-2*
Waste Isolation Pilot Plant (WIPP) *6-1, 6-2, 6-3, 6-4, 6-7, 6-8, 6-11, 6-13, 6-15, 6-16, 6-17, 6-18, 6-19, 6-51, 6-69*
wicking *6-34, 6-83, 6-85, 6-86*